Phosphorus Soil and Fertilizer Management, January 2014

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Intro: Corn and Soil Test Values.

While hybrid selection, nitrogen application, and biologicals (heat units, moisture pattern, soil condition, pest competition) determine the majority of corn yield, we've long known that soil fertility contributes to additional yield enhancement. With the exception of nitrogen, phosphorus is our most limiting nutrient for corn production in West Central Minnesota. Most Olsen-P soil test reports indicate the relative level of available phosphorus with letter designations such as VL (1-3 ppm), L (4-7 ppm), M (8-11 ppm), H (12-15 ppm), or VH (16+ ppm). These letter designations are an index value only, and are used to develop a fertilizer recommendation. Corn yield response to phosphate fertilizer has been well documented in West Central Minnesota. Phosphate response/correlation studies have been ongoing at the West Central Research and Outreach Center for many years.

Yield response to Soil Fertility Level

Yield potential based on phosphorus soil test has been well documented. Studies examining yield potential associated with P soil test levels have been conducted extensively, most recently, from 1991 through 2005 at WCROC. Evidence supports that phosphorus soil test levels greatly influence corn yield when comparing low to medium to high soil tests. Based solely on soil test phosphorus level we can expect a 15% yield decline on a low testing soil when comparing to a medium testing soil. However, when comparing a medium P testing soil to a high P testing soil, yield enhancement is possible with a high test, but not guaranteed, normally in the 5% range, and there are years when no phosphorus response is observed. In a corn-soybean rotation, it will require higher phosphorus application rates to maintain a high soil test verses a medium soil test. So it might make economic sense to maintain a medium soil test and apply P fertilizer on an annual basis to make it behave like a high soil test. So, the question is, what rate of P fertilizer application is required for optimum yield?

Yield response to P fertilizer application, on Medium Testing Soils

Studies conducted on corn yield from a range of broadcast P application rates, on soils testing in the medium P soil test range, were conducted at WCROC from 2004 to 2008 (Table 1). Phosphorus application resulted in significant yield response in 2004 and 2006, but not in 2008. In these 3 years there was no difference in grain yield response between the low P application rate (30/38 lbs P_2O_5) and the high P application rate (50/81 lbs P_2O_5). The response is usually consistent across all P rates: we get the same yield response to 38#P as we do to 81#P. The studies also indicate that yield response to P application on a medium P soil test soil is very probable, but not guaranteed. Year-to-year yields may differ but the yield **improvement from P application** normally stops at about 40# P_2O_5 application rates. This is true for both lower yielding and higher yielding corn years.

Yield response to P_2O_5 applications under high soil test P environments has been shown to be infrequent. In Table 1 (2005) 12 ppm is the lowest index level for a high soil test, but showed no yield improvement under very favorable growing conditions. It may be prudent to maintain P soil test in the medium range with moderate annual P_2O_5 applications.

Table 1. Yield response to phosphorus fertilizer application on medium P testing soils.

	2004	2005	2006		2008
Olsen P	**11ppm**	**12ppm**	**10ppm**		**7ppm**
P_2O_5 Rate lbs/ac	Grain Yield bu/ac	Grain Yield bu/ac	Grain Yield bu/ac	P_2O_5 Rate lbs/ac	Grain Yield bu/ac
0	174 b	212	168 b	0	174
38	201 a	215	186 ab	30	184
49	213 a	219	186 ab	40	182
59	205 a	206	194 a	50	183
70	196 ab	219	184 ab		
81	194 ab	208	192 a		
LSD	0.05	NS	0.05		NS
Sig. Diff.	22 bu	---	19 bu		---
C.V.%	5.1	5.6	5.8		6.8

Soil Test Building

If you are establishing a P fertility program with the goal of maintaining a medium P soil test, you may need to build fertility where your P soil test is low. Soil test building from extremely low levels (3-4 ppm) verses just a low level (5-6 ppm) will likely require more P_2O_5 fertilizer. Two 6-year phosphorus response studies at WCROC (1995-2000 PTCS, George Rehm, U of M Soil Scientist, Barnes/Doland silt loam; and 2009-2014 LTP, Dan Kasier, U of M Soil Scientist, 5 of 6 years completed, McIntosh/Tara silt loam) demonstrate the consequences and difficulties of soil test building. These studies deal with various phosphorus application scenarios, but segments of both studies monitor P soil test change in biennial phosphorus application programs (therefore phosphorus applied in 3 of 6 years in a corn/soybean rotation). As evident from the data in Table 2, building phosphorus soil test from a very low/low (PTCS study, 3-4 ppm) soil test level to a medium test level using biennial applications is a long and expensive process, requiring somewhere between 92# P_2O_5 and 184# P_2O_5 to raise the soil test to medium. When building from a low (LTP study, 5-6 ppm) soil test level to a medium test level using biennial applications, less P_2O_5 is required, about 80# P_2O_5. These two studies illustrate the fertilizer costs (P_2O_5) of letting soil tests drop to very low and/or low levels. Striving to maintain or build to a medium soil test, and then using annual 40 lb P_2O_5 applications for corn, is much more economical then lost yield on low testing P soils, or lost fertilizer dollars on high testing P soils.

Table 2. Fall P soil tests at the beginning of studies in 1994 and 2008, and after 3 biennial applications of P_2O_5 in studies in 1999 and 2013.

	PTCS Study			LTP Study	
	Fall 1994	Fall 1999		Fall 2008	Fall 2013
0# P_2O_5	3/4 ppm (L)	2 ppm (L)	0# P_2O_5	5/6 ppm (L)	5 ppm (L)
92# P_2O_5	3/4 ppm (L)	7 ppm (L)	40# P_2O_5	5/6 ppm (L)	6 ppm (L)
		Medium ?	80# P_2O_5	5/6 ppm (L)	11 ppm (M)
184# P_2O_5	3/4 ppm (L)	13 ppm (H)	120# P_2O_5	5/6 ppm (L)	22 ppm (VH)

Normally in corn production if your soil test is low (L) in phosphorus there is a high probability of a yield response, if your soil test is high (H) there is a low probability of a yield response, and if your soil test is in the medium (M) range there is a good change of response.